- identifying levee-confined channels and banks where routine vegetation removal by local reclamation districts can be safely discontinued; and
- establishing weed control programs to suppress the expansion of tamarisk, giant reed, locust, black fig, and other invasive non-native plants degrading habitat quality and native flora.

Reservoir operations will be evaluated to determine whether winter and spring releases can be augmented with flood simulation spikes every 1-10 years. Simulated flood spikes would mobilize bed and bank deposits to redistribute, sort, and clean spawning gravels and scour deep pools between riffles.

Restoring and enhancing riparian vegetation should be accomplished by eliminating the stressors and recovering or simulating the physical processes and fluvial landforms described above. Vegetation restored in this manner will be more resilient to future disturbances; require little or no long-term maintenance; be self-sustaining; and be more compatible with flood control requirements.

However, vegetation fragmentation and severe limitations of the physical environment will not allow ecosystem processes and functions to fully recover on many segments of valley streams and Delta estuaries. In these solutions, some large-scale stream channel sculpting, gravel additions, and riparian replanting may be necessary. For example, the lower Sacramento River has abandoned river floodplains and sediment is in short supply. Naturally reactivating these habitats would be nearly impossible. Restoring these habitats would require human intervention. Revegetation projects should be contemplated only where native trees and grasses many no longer germinate naturally but have a high probability of unaided survival and vigorous growth following 1-5 years of artificial irrigation.

REFERENCE

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ MAINTAIN HARVESTED SPECIES

INTRODUCTION

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program. Strategic Goal 3 focuses on species which provide sustainable recreational and commercial harvest not already covered by Goal 1:

> *Goal 3: Maintain and /or enhance populations of selected species for sustainable commercial and recreational harvest consistent with the other ERP strategic goals.*

Somewhere between 40 and 50 species of fish and invertebrates are harvested in significant numbers in the CALFED region, as are a number of species of birds (waterfowl, mourning doves, ring-necked pheasants). The ERP has the potential to affect the harvest of many of these species, improving most of them in the long run.

MAINTAIN HARVESTED SPECIES ("H"): For those species designated "H" the CALFED Program will undertake actions to maintain the species at levels which support viable harvest rates. The goal "maintain harvested species" was assigned to species which are harvested for recreational or commercial purposes. A key to maintaining harvestable surplus levels is recognizing the need to recover, contribute to recovery, or maintain species evaluated in the MSCS. Thus, species interactions such as competition and predation and habitat needs for space and flow need to be balanced in favor of species designated for recovery, contribute to recovery and maintain. Those three designations apply only to native species and assemblages while the "maintain harvested species" designation includes some native species and non-native species. Thus, actions implemented to maintain harvested species would be expected, *at a minimum*, to not contribute to the need to list an unlisted species, degrade the status of an already listed species, or impair in any way efforts to recover, contribute to recovery, or maintain native species.

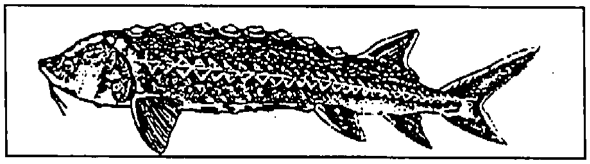
Some species, such as chinook salmon and steelhead trout, are covered by more than one strategic objective. For example, both chinook and steelhead are at-risk species and harvested species and thus covered by the objective to achieve, first, recovery and then large self-sustaining population, and by the objective to enhance fisheries for chinook, steelhead, white sturgeon, Pacific herring, and native cyprinid fishes.

The "maintain harvested species" addressed in this section include:

- chinook salmon *
- steelhead trout *
- white sturgeon
- striped bass
- American shad
- non-native warmwater gamefish
- Pacific herring
- native cyprinid fishes
- grass shrimp
- signal crayfish
- waterfowl *
- upland game.

*Designates species that have previously been discussed. Chinook salmon and steelhead trout were discussed in the section on species designated for recovery and waterfowl were discussed in the section on species communities and assemblages.

◆ WHITE STURGEON



INTRODUCTION

White sturgeon rear in the Sacramento-San Joaquin estuary and spawn in the Sacramento and San Joaquin rivers and their major tributaries. Sturgeon may leave the Bay-Delta and move along the coast to as far as Alaska. Populations of white sturgeon are found in many of the larger rivers from California north to British Columbia.

The white sturgeon is an important native anadromous sport fish with high recreational and ecological value.

Major factors that limit sturgeon populations in the Bay-Delta are adequate streamflows for attracting adults to spawning areas in rivers and transporting young to nursery areas, illegal and legal harvest, and entrainment into water diversions.

RESOURCE DESCRIPTION

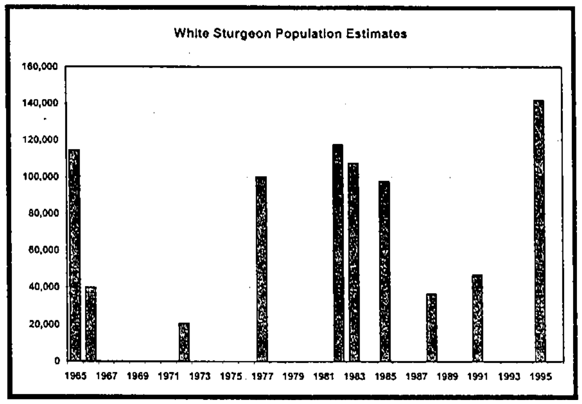
White sturgeon are native to Central Valley rivers and the Bay-Delta and represent an important component of the historic native fish fauna. Throughout recorded history, white sturgeon have been the dominant sturgeon populations in the Bay-Delta system, whereas in smaller systems such as the Eel River, green sturgeon dominate. White sturgeon support a valuable sport fishery in the Bay and Delta.

Sturgeon are long-lived species. Change in abundance of older fish may reflect the harvest of adults and habitat conditions that occurred decades ago during the larval and early juvenile life stages.

White sturgeon inhabit both saltwater and fresh water and tolerate a wide range of salinity concentrations. Spawning occurs in larger rivers upstream of the Delta. Low river flow during late winter and spring may reduce attraction of sturgeon to specific rivers and reduce spawning success. Stream channelization and flood control measures on large rivers (e.g., levee construction) may affect sturgeon use and spawning success.

Losses of sturgeon young into water diversions reduces sturgeon productivity. However, relative to other species, the percentage of the sturgeon population caught in diversions is low.

Food availability, toxic substances, and competition and predation are among the factors influencing the abundance of sturgeon. Sturgeon are long lived (e.g., some live over 50 years) and may concentrate pollutants in body tissue from eating contaminated prey over long periods. Harvesting by sport fishers also affects abundance of the adult populations. Illegal harvest (poaching) also reduces the adult population.



Recently, white sturgeon have been feeding on Asian clams in Suisun Bay, which may indicate a very important ecological role that could feed back through foodweb productivity of the Bay-Delta. Sturgeon predation may limit clam abundance and therefore potentially decrease the loss of plankton to clam feeding. The clams also accumulate contaminants, which may pose a long-term problem for sturgeon feeding heavily on clams.

VISION

The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels.

Restoration would support a sport fishery for white sturgeon and contribute to overall species richness and diversity and reduce conflict between the need for protection for this species and other beneficial uses of water in the Bay-Delta.

White sturgeon would benefit from improved ecosystem processes, including adequate streamflow to attract adults to spawning habitat, transport larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat (including production of food). Ecosystem processes that need improvement include streamflows, stream and channel configurations, and migration barriers (e.g., dams). Additional streamflow during late winter and spring would attract sturgeon to rivers and maintain spawning flow requirements.

White sturgeon would benefit from restoring spawning and rearing habitat. Habitat restoration may be achieved by adding and modifying physical habitat and increasing freshwater flow during critical periods. Juvenile sturgeon frequent Delta sloughs and may benefit from increases in slough habitat. Spawning habitat includes upstream river reaches that contain appropriate substrate (e.g., gravel, rock). Rearing habitat includes areas in the Sacramento and San Joaquin rivers and the Delta that provide protective, food-rich habitats such as the shallow shoals and bays of the Bay-Delta.

Reducing stressors is a component of restoring white sturgeon populations. Reducing losses to diversions from the Sacramento-San Joaquin Delta estuary would increase survival of young sturgeon. White sturgeon would also benefit from actions to reduce pollutant input to streams and rivers in the Sacramento-San Joaquin River basin.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore white sturgeon in the Central Valley would involve cooperation and support from other programs underway to restore sturgeon and other important fish.

- The Central Valley Project Improvement Act (CVPIA) (PL 102-575) calls for implementing changes in flows and project facilities and operations by 2002 that lead to doubling of the sturgeon populations.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 requires DFG to restore historical numbers of sturgeon in the Central Valley.
- The Four Pumps (SWP) and Tracy (CVP) Fish Agreements provide funds and actions to DFG for sturgeon restoration.
- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes (USFWS) identifies recovery actions for white and green sturgeon.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of white sturgeon populations are integrally linked with restoration of river floodplain and stream meander habitat, improvements in Central Valley streamflows, improvements in habitat, and reductions in losses to water diversions and illegal harvest.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to enhance fisheries for salmonids, white sturgeon, Pacific herring, and native cyprinid fishes.

SPECIES TARGET: Meet Native Fish Recovery Plan goals (U.S. Fish and Wildlife Service 1996), which include 100,000 white sturgeon and 2,000 green sturgeon greater than 100 centimeters long as measured in the DFG mark-recapture program.

LONG-TERM OBJECTIVE: Increase white sturgeon numbers (and harvest) by improving habitat conditions for spawning and rearing throughout the Sacramento-San Joaquin estuary and tributaries.

SHORT-TERM OBJECTIVE: Continue to manage white sturgeon for the sustainable sport fishery, without artificial propagation.

RATIONALE: White sturgeon represent an unusual situation: a success story in the management of the fishery for a native species. Numbers of sturgeon today are probably nearly as high as they were in the nineteenth century before they were devastated by commercial fisheries. The longevity and high fecundity of the sturgeon, combined with good management practices of the California Department of Fish and Game, have allowed it to sustain a substantial fishery since the 1950s, without a major decline in numbers. Numbers of white sturgeon could presumably be increased if the San Joaquin River once again contained suitable habitat for spawning and rearing.

STAGE 1 EXPECTATIONS: White sturgeon will continue to support a significant sport fishery in the estuary and will not have experienced a significant decline in abundance.

RESTORATION ACTIONS

General targets for sturgeon populations are:

- Restore population to levels of the 1960s,
- Improve flow in Sacramento River in spring,
- Reduce the rate of illegal harvest,
- Reduce the percentage lost of sturgeon to water diversions to that of the 1960s,

The general approach for programmatic actions are:

- Improve the aquatic foodweb,
- Improve spring flows in Sacramento River and major tributaries,
- Restore natural meander belts and add gravel substrates in upstream spawning areas,
- Increase Delta outflow in spring of dry and normal years,
- Improve water quality of Bay-Delta,
- Provide greater enforcement to reduce poaching,
- Reduce losses of eggs, larvae, and juvenile sturgeon at water diversions,
- Upgrade fish protection facilities at diversion facilities in the Delta,
- Restore tidally influenced Delta and estuarine habitat such as tidal perennial aquatic habitat and sloughs.

REFERENCES

California Department of Fish and Game. 1993. Restoring Central Valley streams: a plan for action. Sacramento, CA.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

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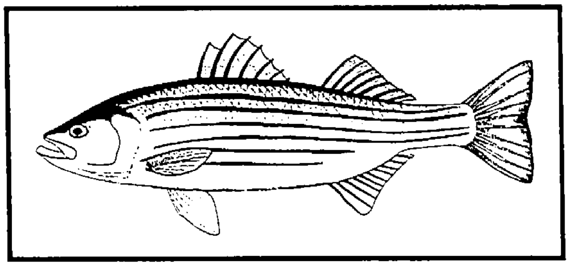


INTRODUCTION

The striped bass is an important non-native anadromous sport fish with high recreation value. It also plays an important role as a top predator in the Bay-Delta and its watershed.

Major factors that limit striped bass contribution to the health of the Delta are streamflow, water diversions, spawning and rearing habitat, legal and illegal harvest, predation and competition from non-native fishes, and reduce survival from contaminants in the water.

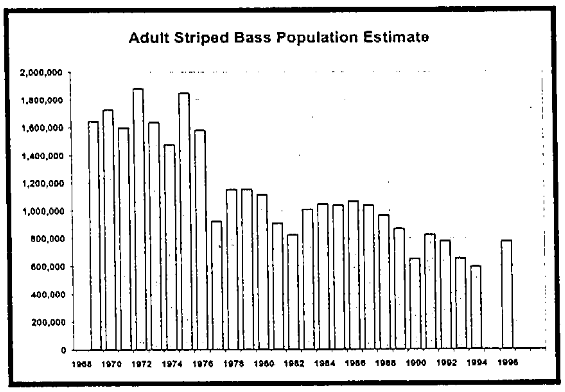
RESOURCE DESCRIPTION

Striped bass were introduced into the Bay-Delta from the east coast of the United States in 1879. For the past century, they have been an important sport fish, commercial fish, and top predator within the Bay-Delta and upstream rivers. They adapted well to the complex habitat conditions of the estuary and remain the premier sport fish of the Bay and Delta. Anglers seek out striped bass along the coast, in the Bay and Delta, and in the lower portions of the Sacramento and San Joaquin Rivers and their tributaries. Striped bass are also an important recreational resource in the waterways of the State and federal water projects south of the Delta.

In the Sacramento River, striped bass are commonly found from Princeton downstream to the Delta and in the lower Feather and American Rivers. In the San Joaquin basin, they are found in the lower Stanislaus, Tuolumne, and San Joaquin rivers. Striped bass spawn primarily in the Sacramento River between Colusa and Sacramento and in the San Joaquin River portion of the Delta.

Juvenile rearing habitat include sloughs, river channels, and bays of the western Delta and Suisun Bay. In wet years young fish rearing habitat extends into San Pablo Bay and adjacent tidal sloughs and marshes. Yearling striped bass are found throughout the Bay and Delta. Adult striped bass are widely distributed from the ocean to the rivers.

The number of adult striped bass and young produced each year have declined dramatically over the past several decades. The total adult population has declined from about 3 million fish in the 1960s to 1.5 million in the early 1970s. More recent estimates are 500,000 to 700,000 adult fish. A greater decline has occurred in older fish, possibly the consequences of greater numbers of older fish migrating to coastal waters, or higher mortality of individual adults from contaminants in the water.



The decline in the adult population of striped bass has been accompanied by a decline in the production of young. The young bass abundance index for summer, when they are 1.5 inches long, has declined dramatically, especially during the recent drought of the late 1980s and early 1990s, and has not recovered. Factors related to and believed to contribute to this decline include the following:

- Low spring flows in the Sacramento River are believed to reduce survival of eggs and larvae by creating poor water quality conditions, reducing plankton food supply, and increasing vulnerability to water diversions.
- Low freshwater flows through the Delta and Suisun Bay may limit the production of food

organisms during critical early life stages of striped bass.

- Low Delta outflow may limit transport of eggs, larvae, and juvenile striped bass into quality nursery grounds of Suisun Bay and away from water diversions in the Delta.
- Higher transport of Sacramento River water across the Delta toward the south Delta pumping plants moves more striped bass young into areas where they are more susceptible to entrainment into agricultural diversions or water project export pumps.

The number of juveniles lost at south Delta export facilities was in the tens of millions in some years during the 1960s to mid-1970s, and again in the middle to late 1980s. The estimated loss in 1974 exceeded 100 million juveniles. Although subsequent export losses have decreased, the rate of loss per unit of population has greatly increased as population abundance has declined.

The number of adult spawners has dropped to such low levels in recent years that there may no longer be sufficient eggs spawned to bring about quick recovery in the population. Good juvenile production even when flows and habitat are excellent for survival is limited by reduced adult spawning populations.

In addition to the low survival of young fish and their low entry into the adult spawning population, mortality rates of adults have increased despite reduced harvest rates in the sport fishery. The higher mortality rates are particularly evident in older adults, and may be a result of effects of toxins, poaching, marine mammal predation, or combinations of these and other factors.

Other factors possibly contributing to the decline and low abundance of striped bass include toxins that reduce survival of young bass or their food supply, competition or predation by recently established, non-native fishes, such as gobies, or poor food production caused by the influx of Asia clams. Both the gobies and Asia clams were introduced from ballast water released from ships from Asia.

Food habit studies conducted by numerous investigators indicate that chinook salmon are not an important component in the diet of striped bass, although, at times, young salmon, primarily fall-run, have constituted a substantial part (U.S. Bureau of Reclamation 1995). Generally, this has occurred in the SacramentoRiver upstream of the estuary and has been localized at water management structures, bridge abutments, and other predator habitats. It also occurs at structures that cause disorientation of juveniles such as RBDD. In the Delta, it is a known problem in CCF and at sites where large numbers of artificially produced chinook salmon are released.

The studies reveal that, except at localized sites and structures, striped bass are less likely to eat salmon in Suisun Bay and the Delta than in the rivers above the Delta. The greater vulnerability of salmon in the river may be a result of the greater clarity and the smaller width of the river. In many areas, bank protection activities, such as maintaining levees and riprapping, have removed SRA habitat and eliminated escape cover needed by young fish.

The U.S. Bureau of Reclamation (1995) reported that the entire striped bass population consumes about 1.4% of the winter-run chinook salmon smolts migration from the Sacramento River. The Bureau also reported that the year-round overlap in the distribution of striped bass and delta smelt resulted in an estimated annual consumption of 195,000 delta smelt, and the striped bass had essentially no impact on splittail.

VISION

The vision for striped bass is to restore populations to levels of abundance consistent with the Fish and Game Commission striped bass policy.

This will support a sport fishery in the Bay, Delta, and tributary rivers, and to reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta.

Over the past two decades, a major focus of striped bass recovery efforts has been Delta outflow enhancement and restrictions on spring and early summer water exports. The recent 1995 Water Quality Control Plan provided interim provisions for improving spring Delta outflows and limiting exports, but did not address summer outflows or effects of water exports in summer or fall. This vision anticipates further improvements in the following:

- spring Delta inflows and outflows in drier years when more flow is needed for successful spawning,
- Bay-Delta foodweb production,
- transporting egg and larval striped bass to nursery grounds in Suisun Bay,
- reducing the effects of water exports from the Delta, especially exports that reverse the natural flow patterns in the Delta.

Although deterioration of habitat may not be a major factor in the decline of striped bass, it could be an important detriment to their recovery. Protecting, improving, and restoring a substantial amount of shallow-water habitat in the Bay and Delta may improve the food supply for striped bass, as well as provide more area for rearing juvenile striped bass. An improved food supply and increased rearing area may help overcome other factors that have little potential for change (e.g., predation and competition from non-native species). Increases in tidal wetlands will provide tidal channels that are important rearing habitat for juvenile striped bass. Improvement and restoration of shallow waters and riparian vegetation along levees and channel islands in the Delta may provide further important habitat for young striped bass. Habitat improvements are expected to also increase the abundance of shrimp and small fish that are important prey of young and adult striped bass and may lead to higher striped bass survival rates.

Reducing the extent and effect of stressors on striped bass will also be important to their recovery. Reducing losses of young striped bass at water diversions in the Delta and Bay, particularly the very high losses at the south Delta pumping plants of the State and federal water projects, will be most important. Improvements are needed to upgrade the two fish protection facilities to reduce the loss of young bass to entrainment into the pumping plants, and to reduce indirect losses to predators associated with the fish protection facilities. Pumping plant operations could also be reduced during periods of high losses.

Longer term actions may involve relocating the pumping plant intakes, screening or reducing the number of small water diversions to agricultural lands in the Delta, and continuing to find ways to reduce entrainment losses into cooling water diversions at two power plant complexes in the Delta. Limiting further introductions of non-native species and reducing the input of contaminants into Central Valley waterways may also be important to striped bass recovery. In the short-term, recovery may depend on supplementing natural reproduction with hatchery and pen-reared striped bass, and possibly reducing illegal and legal harvest. Management actions for striped bass need to be carefully evaluated and structured to avoid adverse affects on native species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore striped bass in the Central Valley would involve cooperation and support from other programs underway to restore striped bass and other important fish.

- The Central Valley Project Improvement Act (CVPIA) calls for implementing changes in flows and project facilities and operations by 2002 that lead to doubling of the striped bass population.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 requires the DFG to restore striped bass in the Central Valley.
- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary that will include provisions to limit entrainment in diversions and protect habitat conditions for Sacramento splittail, chinook salmon, striped bass, and other species.
- Fish and Game Commission Striped Bass Policy: (I) the Department of Fish and Game shall work toward stabilizing and then restoring the presently declining striped bass fishery of the Sacramento-San Joaquin Estuary. This goal is consistent with Commission policy that the Department shall emphasize programs that ensure, enhance, and prevent loss of sport fishing opportunities. (II) The Department shall ensure

that actions to increase striped bass abundance are consistent with the Department's long-term mission and public trust responsibilities including those related to threatened and endangered species and other species of special concern. Recognizing issues associated with potential incidental take of these species, an appropriate interim objective is to restore the striped bass population to the 1980 population level of 1.1 million adults within the next 5-10 years. (III) the long-term striped bass restoration goal, as identified in the Department's 1989 Striped Bass Restoration Plan, is 3 million adults. (IV) The Department shall work toward these goals through any appropriate means. Such means may include actions to help maintain, restore, and improve habitat; pen-rearing of fish salvaged from water project screens; and artificial propagation. (*Adopted 4/5/96*) (Fish and Game Code 1997).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Because striped bass are predators, they could affect efforts to recover populations of a number of native fishes of the Central Valley including chinook salmon, steelhead, delta smelt, longfin smelt, and Sacramento splittail. Consequently, it will be necessary to consult and cooperate with the National Marine Fisheries Service and U.S. Fish and Wildlife Service under the federal Endangered Species Act (ESA) and DFG under the California ESA.

OBJECTIVE, TARGETS, AND ACTIONS

The Strategic Objective is to maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.

SPECIES TARGET: Restore the adult population (greater than 18 inches total length) to 1.1 million fish within the next 10 years. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities.

LONG-TERM OBJECTIVE: Restore the adult population (greater than 18 inches total length) to 3 million fish through such actions as improving, maintaining, and restoring habitat, pen-rearing of fish salvaged at water project screens, and artificial propagation. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities.

SHORT-TERM OBJECTIVE: Restore the adult population (greater than 18 inches total length) to 1.1 million fish within the next 10 years. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities.

RATIONALE: The striped bass is a non-native species that is a favorite sport fish in the estuary. It is also the most abundant and voracious piscivorous fish in the system and it has the potential to limit the recovery of native species, such as chinook salmon and steelhead. Therefore, the management for striped bass must juggle the objectives of providing opportunities for harvest while not jeopardizing recovery of native species. An appropriate policy may be to allow striped bass to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially artificial propagation. Artificially reared bass have the potential to depress not only native fish populations but also populations of wild striped bass, because larger juveniles (of hatchery origin) may prey on smaller juveniles (of wild origin). If increases in bass numbers appear to adversely affect recovery of native species, additional management measures may be required to keep bass numbers below the level that pose a threat to native species.

STAGE 1 EXPECTATIONS: Continue investigations into the causes of striped bass decline throughout the Sacramento-San Joaquin Estuary. In addition, all efforts shall be undertaken to ensure that programs are developed that ensure, enhance, and prevent the loss of sport fishing opportunities.

Restoration Actions

General targets for striped bass are:

- restore population to levels of the 1960s,
- maintain flow in the Sacramento River at Sacramento at 13,000 cfs in the spring,
- improve health of average individual striped bass in population,
- reduce the rate of illegal harvest of striped bass, and
- reduce the percentage of young striped bass lost to entrainment at water diversions.

General programmatic actions which will help to meet the targets for striped bass include:

- protect and restore shallow water, tidal slough, and wetlands habitats,
- improve aquatic foodweb,
- maintain 13,000 cfs flow in lower Sacramento River in the spring months of all but driest years,
- increase Delta outflow in spring of dry and below normal years,
- reduce the introductions of non-native aquatic organisms into the Bay-Delta,
- improve water quality of the Bay-Delta,
- provide greater enforcement to reduce illegal harvest,
- reduce losses of eggs, larvae, and juvenile striped bass at water diversions,
- upgrade fish protection facilities at south Delta pumping plants and power generation plants in the Delta, and
- supplement striped bass population with pen-reared and hatchery-reared striped bass, as needed, until natural production is adequate to sustain the population at target level.

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